graphic print of the iris of the eye does not afford a trustworthy unit of measurement.

FRANCIS GALTON

ON THE ALGIC FLORA OF THE ARCTIC SEAS

AMONG the fields of research opened to science by the Swedish Arctic expeditions of recent years the botanical one is that which has been cultivated the most assiduously and with the best results. The contributions which Swedish men of science have made to our knowledge of the flora of the Arctic regions are varied as well as important. They embrace the higher as well as the lower forms, both the species invisible to the naked eye as well as those of greater size, and the varieties hidden in the lap of the ocean as well as those which the student encounters on *terra firma*. Swedish botanists have particularly increased our knowledge of the remarkable flora of the sea. Thus instead of, as only a few years ago, our being ignorant as to whether there really was a flora at the bottom of the Arctic seas or not, we are now more familiar with the algæ flora of these regions than many another in far more southern latitudes.

Of the Swedish botanists who have particularly devoted their time and energy to the study of the flora of the Arctic seas I must mention the following gentlemen, members of the Royal Academy of Science of Stockholm: Messrs. J. G. Agardh, P. T. Cleve, F. R. Kjellman, and E. G. Kleen. The reason which specially prompts me to discuss this subject here is the recent appearance of an important work by one of these algologists, Prof. Kjellman, viz. "Norra Ishafvets Algflora," with thirty-one illustrations, which forms part of Nordenskjöld's "*Vega*-expeditionens vetenskapliga iakttagelser," a work which has from time to time received favourable mention in this journal.

Prof. Kjellman has, as the representative of botany, and particularly the branch termed algology, participated in four Arctic expeditions, during which he has visited Finmarken, Spitzbergen, Novaya Zemlya, in Europe, and long stretches of the coast of Siberia, in Asia. Two of these expeditions, the one to Spitzbergen, 1872-73, and the *Vega* Expedition, 1878-80, were attended by winterings in the Arctic regions, during which time Prof. Kjellman enjoyed an opportunity, never before accorded to an algologist, viz. that of studying the flora of the sea *at all seasons*. His algæ flora, in consequence, not only forms a complete index of the species and varieties of the algæ of the Arctic seas, their form, construction, and geographical distribution, but it gives us also an insight into the vital functions of these plants, and explains to us the conditions under which they exist. I intend in this paper to refer briefly to the present position of this science, to which Prof. Kjellman has contributed such a great share.

The Arctic Ocean covers, geographically speaking, the sea north of the Polar Circle. Within this area there is, however, a vast tract of sea where there is no ice either winter or summer. This is the sea around Northern Norway through which the Gulf Stream flows. On the other hand, there are tracts south of the Polar Circle which rival the coldest parts of the Arctic Ocean on the point of ice. To these belongs, in the first instance, the part of the Atlantic washing the south-eastern shores of Greenland, which receives from the north a cold Polar current full of icebergs.

From a hydrographical point of view, however, the Arctic Ocean is far more naturally limited if we deduct from it the part around Northern Norway and add to it the sea around Southern Greenland. From a botanical point of view, too, the Arctic Ocean is thus limited in a more natural manner. To the part of the Arctic Ocean cut off by this arrangement Prof. Kjellman proposes to assign the name "The Norwegian Polar Sea," and in the work referred to above he deals with the algæ flora of the true Arctic Ocean, according to the hydrographical and botanical theories, as well as that of the Norwegian Polar Sea. As the conditions under which the flora of the true Arctic Ocean lives lend to the same a heightened interest, I will discuss this flora at more length, and finally add some words on that of the Norwegian Polar Sea.

In a sea like the Arctic Ocean, where ice is found in large quantities all the year round, it seems, at first sight, that no flora could exist, and it is, indeed, true that great parts of the Arctic Ocean are, botanically speaking, mere deserts, but this is not caused, as I will presently show, by the low temperature of the sea, but by other causes. Strangely enough, some algæ have become accustomed to be surrounded by a medium the temperature of which never, or at all events but seldom, rises above freezing-point, and in many instances they have indeed flourished greatly therein, of which their luxuriant growth bears evident proof.

When I just said that large tracts of the Arctic Ocean are botanically deserts, I did not thereby mean that the *deepest* parts of the sea were void of flora, as this is really the case in all, even the warmest, parts of the oceans of the globe. The algæ flora is only to be found within a smaller or larger belt along the coasts of the continents and islands, and even within this belt, where the depth does not prevent the existence of algæ, they are not found everywhere. Another condition too must be present for the existence of algæ, viz. that the bottom be rock, boulders, or marine shells, in brief, formed of large objects which can serve as "moorings" for them. Thus, where the bottom is sand or clay the regular algæ flora is absent. In the eastern parts of the Arctic Ocean the latter kind of bottom is very common. Nearly along the entire coast of Siberia, and in long stretches near Novaya Zemlya and Spitzbergen, the bottom is formed of fine sand and clay. Algæ are here sought in vain, as they are, in fact, in localities with a similar bottom all over the world. Only on the north and north-western coasts of Spitzbergen, and in several places along the west coast of Greenland, the bottom consists of such hard materials as are favourable to a copious algæ flora.

This explains to a great extent the existence of the botanical deserts, referred to above, in the Arctic Ocean, but there are also other causes. Before I deal with these, however, I must explain the manner in which the bottom of the Arctic Ocean is divided according to the flora at various depths, as suggested by Prof. Kjellman.

He distinguishes between three bottom regions, viz. the *littoral*, or what may be called the upper shore-belt, the *sub-littoral*, or lower shore-belt, and the *elittoral*, or deep-sea belt. The upper shore-belt embraces that part of the bottom which lies between the neap and high tides, the lower shore-belt the part that stretches from the former down to a depth of 36 metres, and the deep-sea belt the part below the latter depth.

Of these three belts, one, the upper belt, contributes greatly, and in a striking manner, to make parts of the Arctic Ocean flora-less. Within far the largest parts of the ocean this belt is void of all vegetation, and the cause of this is easily discovered. It lies in the ice. Thus every winter a girdle of coarse, firm ice is formed along the coast, and near the shore reaches to the bottom. In some places this ice lies all the year round, and in others it certainly disappears, but generally late in the season. At Cape Chelyuskin during the *Vega* Expedition the "ice-foot," viz. the shore-ice, was lying firm at the end of August. Where the land-ice thus remains throughout the summer no algæ can, of course, develop, and where it disappears only in the autumn the time is too short to allow of any growth.

Nearly as detrimental to the flora as the land-ice are the broken-up ice-masses, which during the summer are driven hither and thither by winds and waves. These

drift-ice masses grind the upper shore-belt to such an extent that every vestige of vegetation is decimated, if not entirely destroyed. The tide contributes also greatly to increase the disturbing influences of the ice, as by this phenomenon the area of shore exposed to the action of the ice becomes greatly increased, and by the circumstance that the ice-masses are thereby kept in *constant* motion. Not even in the winter are the ice-masses at rest along the shore. During the wintering of the Swedish expedition at Spitzbergen at the northernmost promontory of that island the sea outside the station, Mossel Bay, was covered with hard, coarse ice, some twenty miles in breadth. Still throughout the wintering a grating sound was heard from the ice, caused by the rubbing of the ice-floes and icebergs against each other as they moved backwards and forwards, or rose and fell. That a similar action would greatly affect the bottom of the sea is quite evident, particularly as most of the shores of the Arctic Ocean are void of the protection afforded by islands and fjords. The latter contribute to increase the detrimental effect of the ice on the algæ flora. On an open coast the action of the ice is, of course, more violent than where it is protected by islands. For this reason the upper shore-belt is nearly everywhere in the Arctic Ocean void of algæ where there are no protecting islands, as, for instance, on the shore of North-Western Spitzbergen, on a few places at Novaya Zemlya, and particularly at the west coast of Greenland.

Another circumstance which greatly contributes to the poorness of the algæ flora in several parts of the Arctic seas north of Asia is the brackishness of the water, caused by the great Siberian rivers. The water of the surface here consists of two parts river-water and one part sea-water, a condition which is very detrimental to the development of algæ.

The total absence of light in certain parts of the Arctic regions during a very great part of the year also arrests the growth of certain algæ which love the light. The scarcity of green algæ is, no doubt, due to this circumstance.

It is natural to assume that the temperature of the Arctic seas is low, but it is really lower than is generally believed. Thus, during the warmest part of the year, in the month of July, the mean surface temperature is from $+ 0^{\circ}{\cdot}11$ C. in the American Arctic Sea to $+ 3^{\circ}{\cdot}3$ and $4^{\circ}{\cdot}33$ in the sea around Spitzbergen and the Murman coast, and it decreases greatly with the depth. At the depths at which the algæ flora is richest, it never rises above 0° C. That many species of algæ are excluded from the Arctic seas by this low temperature is evident. It is, indeed, to be wondered at that there are algæ in these icy waters at all; but that there are really many I will presently show.

From what I have thus said, it appears that the algæ-covered spots in the Arctic seas are, so to speak, oases in the great Polar water desert. Let us now examine the conditions of the flora in these oases. Most of them have but a poor and sparse vegetation. This is particularly the case in the Siberian seas and the eastern part of the Kara Sea, and, to some extent, in the western part of the Kara Sea, the eastern part of the Murman Sea, the Spitzbergen Sea (the sea to the east of Spitzbergen), and the Greenland Sea (the sea between Greenland and Spitzbergen). Even where the quantity of algæ is greatest within this area, it is much less than in the richest parts of the Atlantic Ocean. In the western part of the Murman Sea and the White Sea the vegetation is not so poor (according to Chr. Gobi, "Die Algen flora des Weissen Meeres und der demselben zunächst liegenden Theile des nördlichen Eismeeres," 1878). It is richest in Baffin's Bay, on the west coast of Greenland. The greatest authority on the natural history of Greenland says on this point: "Just outside the coast of Greenland the sea-bottom is covered with a forest of giant algæ, with leaves from 12 to 16 feet in length and half a foot in width, besides which the stones are everywhere covered with coral-like layers (coral algæ)." The algæ flora in this spot is, therefore, copious, and is far in advance of those in other parts of the Arctic Ocean.

I have already said that the bottom of the Arctic Sea may be divided botanically into three belts, viz. the upper shore, the lower shore, and the deep-sea belt. Of these the first-named is the poorest, the algæ oases here being few and limited, the vegetation poor in individuals, and the algæ very small. The west coast of Greenland, with its fjords and islands, alone forms an exception in this respect. The upper belt here often produces brown algæ of considerable size (*Fucaceæ*), while even green and red are not wanting. The deep-sea belt is, like the upper one, poor in species and individuals. During the Swedish Arctic expeditions only six species have been discovered in this belt, and all of these lived at a considerable depth, one (*Ptilota pectinata*, Gunn.) even at a depth of 270 metres. The principal flora of the Arctic Sea belongs, however, to the lower shore-belt. This belt everywhere possesses the largest and the greatest number and variety of algæ. Its characteristic forms are two, viz leaf-weed algæ (*Laminarieæ*) and coral algæ (*Corallinaceæ*). They cover large areas of the bottom, and appear in close masses rich in individuals, which attain a great size. The leaf-weed algæ make the greatest impression; they derive their name from the circumstance that they carry a large leaf at the top, which is shed and renewed annually. All species belonging to this family are large algæ, some of them attaining a length of 4 metres, and the top leaf a width of 1 metre. They are the *trees* of the sea, and resemble those on land by growing together in forests. These are the algæ which in the Arctic Ocean attain the greatest size and cover the largest area, and so greatly contribute to the general habitus of the flora of this ocean that one might justly call it the "Ocean of the Laminarieæ."

Next to the Laminarieæ the Corallinaceæ are the most important. These algæ form one of the wonders of the terrestrial flora. Any one who thus sees them for the first time would think that they were real corals or some kind of stone. They are—as they appear in the Arctic seas—perfectly hard, being impregnated with chalk, and have a peculiar soft rosy or grayish-red colour. In form they vary between the laminated and the bushy. Often, too, they appear as detached ballss which have on their surface shorter or longer branch-like projections. These balls may attain a diameter of 20 centimetres, as, for instance, in *Lithothamnion glaciale* (Kjellm.), and appear in certain places in the Arctic seas in enormous quantities. On the shores of Spitzbergen and Novaya Zemlya, for instance, the bottom of the sea is for miles covered by deep layers formed of such balls, which, as Prof. Kjellman remarks, must be of great importance in forming fresh earth-crusts. All the other species of algæ play a very subordinate *rôle* compared with the Laminarieæ and Corallinaceæ. They are certainly, as regards variety of forms, superior to these latter, as the leaf-weed algæ possess only twenty species and the coral algæ nine, while other Arctic algæ—with the exception of Diatomaceæ—have as many as 145 species. In spite, however, of the abundance of the species of the latter, they make but little impression in the algæ flora, as they are either too small, or too few in the number of individuals. This being the case, it is only natural that the Arctic sea-flora, particularly owing to the predominance of the Laminarieæ, is monotonous in its appearance. This does not indeed apply to form alone, but also to colour. The colour is really sombre, the brown colour of the Laminarieæ predominating. The lighter-brown shades are almost entirely wanting. The red algæ (*Florideæ*) are not very prominent, with the exception of the coral algæ within their special sphere, and their colour is not, as I have observed, of the strongest or purest. The chlorophyll algæ are very insignificant. The many variations of green—from the freshest

grass-green to the white and yellow green—which give such richness of colour to the vegetation in the Atlantic Ocean, are almost entirely absent in the Arctic seas.

I have already mentioned that leaf-weed and coral algæ attain a great size in the Arctic Ocean. This is also the case with a considerable number of other Arctic algæ. Thus, the brown algæ, *e.g. Desmarestia aculeata*, L., and *Dichloria viridis*, Müller, and the red algæ, *Delesseria sinuosa*, G. and W., and *Halosaccion ramentaceum*, L., as well as the green algæ, *Monostroma Blyttii*, Aresch., and *Chætomorpha melagonium*, W. and M., show a high degree of development; a fact which proves that these algæ not only endure, but are quite at home in, the Polar water.

Another feature of great interest relating to the subject are the biological conditions of the algæ flora. Algæ which conclude their existence in a single year are either wanting, or at all events very few. Nearly all Arctic algæ live several years, and in order that they may be able to effect the work of propagation and nourishment with the little supply there is of heat and light, their organs are in operation during the dark as well as the light season. Whilst wintering at the northernmost part of Spitzbergen in 1872-73, Prof. Kjellman observed in the middle of the winter, viz. at a time when the sun was lowest and the darkness therefore most intense, that a considerable development and growth of the organs of nourishment took place, while, as regards the organs of propagation, he found that it was just at this season that they were most developed. Spores of all kinds were produced and became mature, and they developed into splendid plants. The Arctic algæ therefore present the remarkable spectacle of plants which develop their organs of nourishment, and particularly their organs of propagation, all the year round, even during the long Polar night, growing regularly at a temperature of between -1° and -2° C., and even attaining a great size at a temperature which never rises above freezing-point.

The result at which Prof. Kjellman arrived with regard to the development of the Arctic flora was this, that the algæ flora of the Arctic Ocean is, contrary to the Phanerogamic flora, not an immigrant flora, but that its origin lay in the Polar Sea itself. This theory is, he believes, proved by the facts that (1) the Arctic algæ flora is rich in endemic species, these being not fewer than 37, or 22 per cent. of the whole flora); and that (2) there are many species found both in the Northern Atlantic and the Pacific Oceans a large percentage of which reaches very far north in the Arctic Sea, and which have attained a high degree of development there, being characteristic algæ of the Arctic Ocean. That the endemic species owe their origin to the Arctic Ocean cannot be doubted; and that the species referred to under (2) have been originated there and gradually spread to the other two oceans is more than probable. If this be so, Prof. Kjellman estimates the number of species whose origin must be referred to the Arctic Ocean at 100, *i.e.* about 60 per cent of the entire algæ flora.

There remain now but a few remarks to make on the algæ flora of that part of the Arctic Ocean which has been named the Norwegian Polar Sea.

If sufficient notice be taken of the geographical position, this sea may be said to be the most favoured on the globe in the way of temperature. Although north of the Polar Circle, and reaching thence to 72° N. lat., it is never frozen, not even along the coasts. The mean temperature of the sea at the North Cape during the coldest season, viz. March, April, and May, is $+3^{\circ}$ C., and during the true winter months, December to February, $+3^{\circ}{\cdot}03$ C. If to this be added that the water is very salt, and that the bottom nearly everywhere consists of rocks or boulders, and that the coast is full of fjords and islands, every condition for the development of a rich algæ flora is present. And indeed the flora here is more copious than in the true Arctic Ocean. There are no large deserts here. The upper shore-belt is covered with algæ, while brown algæ (*Fucaceæ*) are found everywhere, sometimes less, sometimes more mixed with red and green ones. The lower belt is the home of the leaf-weed algæ, most of which belong to other species than those of the true Arctic Sea. The coral algæ, too, are well represented, and even these differ from those of the true Arctic Sea in possessing brighter colours. The number of red algæ belonging to other groups is also greater than in the true Arctic Sea. The total number of algæ species in the Norwegian Polar Sea is 194, a number which is very great when we remember its limited area. There are in the true Arctic Sea, which is so much larger, only 174 species.

With regard to the general character of the algæ flora of the Norwegian Polar Sea, it must be described as a mixed flora, made up of species belonging partly to the Arctic and partly to the Atlantic Oceans, and some endemic ones. Prof. Kjellman believes, and in this I entirely concur, that the former are the original species characteristic of the spot, and that they are remnants from the time when the Arctic Ocean was larger than it is at present, *i.e.* during the Glacial period. The Atlantic species have immigrated during more recent times with the Gulf Stream, as they have by degrees become so prominent that the algæ flora of the Norwegian Polar Sea must, on the whole, now be referred to the Atlantic Ocean.

It has already been said that the algæ flora of the west coast of Greenland occupies a transitory position between that of the North Atlantic and that of the true Arctic Ocean. According to W. G. Farlow ("Marine Algæ of New England and Adjacent Coasts," 1881) this is far more the case with the algæ flora of the northern parts of the United States, and it may be of interest to note that by the aid of the Polar current flowing there a considerable number of true Arctic algæ have succeeded in penetrating to the forty-second degree of latitude, *i.e.* the latitude of Central Italy, or perhaps, more correctly speaking, have remained on the shores of New England from the very period when the Arctic Ocean extended thither at the time of the Glacial Age.

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NOTES

WE are glad to learn that the trustees have appointed Prof. Newcomb Professor of Mathematics and Astronomy in the Johns Hopkins University, and that he has agreed to accept the position. The University begins the session with 273 students, of whom 160 are graduates, and the attendance is distributed well through all the departments. Sir William Thomson's lectures, as might be expected, were a great success.

THE following changes are proposed to be made in the Council of the London Mathematical Society for the ensuing session:—Prof. Sylvester, F.R.S., and Prof. Greenhill are nominated to fill up the places vacated by the late Prof. Rowe and Mr. W. D. Niven, F.R.S. Mr. J. W. L. Glaisher, F.R.S., has been selected for the Presidentship, while Dr. Henrici, F.R.S., Prof. Sylvester, F.R.S., and Mr. J. J. Walker, F.R.S., have been nominated Vice-Presidents. In consequence of Dr. Henrici's not having yet returned from his visit to Canada and California, it is not yet certain whether he will deliver his retiring address at the annual meeting (November 13), or defer its delivery to a later date in the session. It is proposed to present the De Morgan Memorial Medal to Prof. Cayley, F.R.S., its first recipient, at the annual meeting.

LORD M'LAREN AND MR. JOHN MURRAY, two of the directors of the Ben Nevis Observatory, ascended Ben Nevis last week